PHYTOTOXICOLOGY ASSESSMENT SURVEY INVESTIGATION IN THE VICINITY OF CRANE CANADA LIMITED STRATFORD, 1989

JANUARY 1992

Ontario
Environment
Environnement

ISBN 0-7729-9197-9

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Air Resources Branch
Ontario Ministry of the Environment

JANUARY 1992

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PIBS 1768

Introduction

In 1976, the Southwestern Region requested that the Phytotoxicology Section undertake a vegetation and soil surveillance in the vicinity of Crane Canada Limited in Stratford. Because of the nature of activities at the plant, (manufacture of bath tubs, sinks, etc.) the Region suspected that Crane might be a significant source of boron emissions.

Analyses of foliage collected during the initial Phytotoxicology survey in 1977 indicated the presence of excessive boron values (over 200 ppm) at Site 1. In 1978, survey results indicated that excessive values of boron in vegetation were present at Sites 1 and 6, and that values at Site 1 increased from 366 ppm in 1977 to 667 ppm in 1978.

In both 1977 and 1978, foliar samples were also analyzed for a number of heavy metals. Results showed that lead, zinc, cadmium, iron and copper concentrations were not excessive and no pattern of deposition related to the plant was evident.

As a result of these initial findings, the annual vegetation survey was expanded to include additional sites (including soil sampling) and dedicated to the monitoring of boron emissions exclusively. In 1982, soil samples were collected from Sites 1 and 12 (control) for the determination of available boron values. Results consistently showed that the 6.3 ppm average found in the soils obtained from Site 1 was significantly above tne 1 ppm level considered potentially phytotoxic. At Site 12, tne average level was 0.2 ppm.

Based on the Phytotoxicology survey reports and a 1988 health-related complaint lodged by a nearby resident, abatement officers from the Ministry's London office met with Crane officials in late 1989 to discuss company emissions and abatement strategies. Pending Ministry approval, Crane has agreed to install a water bath system in the spray booth area to trap and prevent overspray materials from reaching the exterior environment. The company expects the water system to be installed during the summer vacation period (July-August) in 1990.

1989 Surveillance Activities

Vegetation

On August 28, 1989 the Phytotoxicology Section conducted the annual vegetation surveillance visit at 10 previously established sites in the vicinity of Crane Canada and at an additional new site (14). Figure 1 shows the locations of the survey sites around the plant. As the figure shows, site 14 is situated directly across the road from Crane.

At each site, foliage of survey trees facing the plant was examined for evidence of injury symptoms induced by industrial air pollutants. Such injury was noted and rated according to the standard Phytotoxicology injury severity scale. Leaf samples which displayed typical boron-type symptoms were collected for retention by the Phytotoxicology herbarium.

Following the observational phase of the survey, duplicate samples of the examined foliage facing the Crane plant were collected for chemical analysis. All samples were returned to the Phytotoxicology laboratory in Toronto for pre-analysis processing according to a standardized 'not washed' method. Processed samples were submitted to the Ministry's Inorganic Trace Contaminants Laboratory (ITC) for the determination of boron, fluoride and 10 other elements.

Field Observations

The 1989 surveillance visit was conducted on August 28 in order to ensure that foliar injury induced by air pollutants would not be obscured by senescence. The visible injury ratings obtained during the 1989 surveillance have been listed in Table 1 along with those from 1984 to 1987. No survey was undertaken in 1988.

The silver maple and green ash foliage at survey Site 1 were the most severely injured (>35% of leaf surfaces) of all vegetation species associated with the surveillance program. Moderate to severe injury (11-35%) was again observed on Norway maple foliage at site 4 as well as at 14. All injury symptoms appeared to be characteristic of boron. Compared to 1987, injury ratings on the 1989 foliage increased at 5 sites, decreased at one site, and remained unchanged at 7 sites.

Chemical Analysis Results - Vegetation

Boron

In order to provide a historical perspective of boron concentrations found in unwashed foliage collected in the vicinity of Crane Canada Ltd., chemical analysis results from 1977 to 1989 have been assembled in Table 2.

Boron values which are in excess of the Phytotoxicology Upper Limit of Normal Guideline (ULN) have been underlined. The rationale behind the development of the ULN guideline appears in Appendix I. Note that the boron ULN was revised in 1985 (down from 200 ppm to 175 ppm) as a result of the adoption of the statistical basis for calculation discussed in the Appendix.

The highest boron values continue to be found at sites relatively

close to the Crane plant. At site 1, values detected in the silver maple and green ash were 880 ppm and 420 ppm in 1989, respectively. Values of 370 ppm were found at site 4, 515 ppm at site 6 and 835 ppm at site 14.

The 1989 boron value (250 ppm) found in the silver maple foliage at site 10 was above the Phyto ULN of 175 ppm. A much lower value of 70 ppm was found in the Norway maple foliage at the same location.

Boron values detected in selected vegetation at each survey site were plotted in a computer-generated program (Surfer™) to produce a contamination contour map (Figure 2). At sites where both maple and ash foliage were collected (1 and 12), only the maple data were used for the contour maps. At sites where both silver and Norway maple foliage were collected (8 and 10), only data from the silver maple foliage were used for the contours.

Although the contour values (lines) at each survey site are placed accurately, the configuration of the lines between sites is based on computer-generated extrapolations of where the lines should be, based on the data. Nevertheless, the figure clearly demonstrates that the Crane plant is central to the high boron values detected in the vegetation and generally delineates the approximate size of the area affected. The contours also demonstrate that values decrease with increasing distance from the plant.

Fluoride

Average fluoride values found in 1989 foliage appear in Table 3. Values above the 35 ppm ULN guideline in the table have been underlined. The data show that excessive values of the element were detected in foliage at 7 of 11 survey sites, with the highest values occurring at the 3 sites (1, 6 and 14) closest to the Crane plant. An average fluoride value of 290 ppm was found in the Norway maple foliage at site 14, 200 ppm in the silver maple and 175 ppm in the green ash foliage at site 1, and 195 ppm in the silver maple foliage at site 6.

A computer-generated contour map (Figure 3) was created and demonstrates the relationship between high fluoride values and the Crane plant. Clearly, the highest values were found in foliage at survey sites close to the Crane plant, and values declined sharply at sites located farther from the plant. The similarity of the boron and fluoride contour patterns in relation to the Crane plant clearly indicates that this industry is the source of the two elements.

Other Elements

A group of ten other elements was examined in the survey foliage collected in 1989 near the Crane plant (Table 4). ULN guidelines for

most elements appear at the base of the table for reference purposes. Values in the table which exceed the guidelines are underlined.

Excessive values of nickel were found in the silver maple and green ash foliage collected from site 1 and in the Norway maple at site 14. Values of copper which exceeded the ULN guideline were found in the foliage of both trees at site 1 and in the green ash foliage at control site 12. Although excessive values of copper and nickel were not found at the remaining sites, the contour maps show a definite relationship between higher values and proximity to the Crane plant (Figures 4 and 5).

Although values of zinc, aluminum, barium and titanium did not exceed established ULN guidelines, they were more elevated at sites closest to the Crane plant and considerably higher than control values. Contour maps generated for each of the elements demonstrate the relationship between higher values and close proximity to the plant (Figures 6, 7, 8 and 9). The iron, lead, sulphur and manganese foliar concentrations compare favourably with their respective control data and do not appear to be related to distance and/or direction from Crane.

Air Monitoring Surveillance – Moss Bags

The establishment of a comprehensive moss bag air monitoring network in the area surrounding the Crane plant was initiated in 1989. The primary purpose for the use of moss bags was to quantify the level of current airborne emissions of boron, fluoride and other elements, compared to that which may be entrained in the soil and absorbed by the vegetation. It was also hoped that the data from the moss bag at site 10 would help explain the anomalously elevated foliar results at that location.

Moss bags have been used successfully for many years to monitor atmospheric emissions from a variety of industrial sources. Bags used by the Phytotoxicology Section consist of laboratory-washed and selected Sphagnum moss fibres. Three grams (+ 0.1 grams) of processed mosses are contained within a bag of polypropylene screening measuring approximately 15.5 cm x 6.5 cm, which provides a moss surface area of 100 cm^2.

A moss bag network consisting of 13 sites was established on 10 May 1989. Bags were exchanged monthly until the final harvest on 10 September 1989. At most locations, bags were fitted to a plastic holder which was then affixed to a telephone pole or tree. Where suitable mounting structures were unavailable (sites 1, 12 & 15), moss bag holders were affixed to the top of a wooden rod which in turn was fitted into a hollow square metal pole driven into the ground. Regardless of the mounting arrangement, all bags were orientated so that they faced the Crane plant and were positioned approximately 3 metres from the

ground.

As Figure 1 shows, bags were established at all existing vegetation and soil survey sites and at 2 additional locations, in order to provide more extensive coverage. All exposed bags were stored until the conclusion of the program so that all bags could be submitted for analysis as a group.

Moss bags were processed unwashed in the Phytotoxicology laboratory and submitted to the Ministry's ITC group for analysis to determine the concentrations boron and fluoride as well as 8 other elements.

Chemical Analysis Results - Moss Bags

Values of boron, fluoride and 8 other elements found in moss bags exposed during each of the three monthly periods appear in Tables 5, 6, and 7. Phytotoxicology ULN guidelines have only been formulated for copper and zinc. Clearly, the levels of boron, fluoride, sodium, barium, titanium, copper and zinc during each of the monthly periods were elevated at 3 sites close to the plant (1, 6 and 14). Contour maps showing the locations of the sites with elevated values for 5 of the elements during the three monthly exposure periods appear in Figures 10 -14. Although the shape and direction of contour lines have been infuenced by prevailing winds, the maps demonstrate the close monthly relationship of elevated moss bag values with proximity to the Crane plant.

Boron values detected in moss bags during each of the 3 monthly exposure periods were relatively low at site 10. This suggests that the high boron value found in the silver maple foliage at this site (Table 2) is not a result of current emissions.

Soil Surveillance

Surface soils (0-5 cm depth) were sampled at two original survey sites (1 and 12) in 1982. Samples were analyzed by the hot water extract method to determine available boron values. The average value of 6.6 ppm found at site 1 was considerably above the 1 ppm considered to be potentially phytotoxic. The available boron value at site 12 in 1982 was 0.2 ppm.

In 1989, soils were sampled at all ten original sites plus site 14. Duplicate samples of surface soils (0-5 cm depth) and deeper soils (25-30 cm) were collected for analysis. Samples were submitted to the ITC laboratory for boron (available) analysis.

Chemical Analysis Results - Available Boron

Values of available boron found in soils collected at all 11 survey sites in the vicinity of Crane Canada Ltd. have been assembled in Table 8. The data show that available boron in 0-5 cm soils above the 1 ppm phytotoxic level was detected at sites 1, 4, 6 and 14. The highest value was found at site 14 (6.3 ppm) followed by site 1 (5.1 ppm).

At site 10, a value of 0.8 ppm was detected in both the 0-5 cm and 25-30 cm soils. Although the values were below the 1 ppm considered to be potentially phytoxic, they are nevertheless surprisingly elevated when compared to much lower values found at other survey sites located closer to the Crane plant.

At the deeper 25-30 cm level, available boron values above 1 ppm were also found at sites 1, 4, 6 and 14. At this depth, the highest values occurred at site 1 (4.5 ppm) and site 6 (2.4 ppm).

The data indicate that boron emissions have contaminated both surface (0-5 cm) and deeper soils (25-30 cm) near the Crane plant. Since the soils at all sites are considered undisturbed, the high available boron values found at the deeper level (25-30 cm) would suggest that boron has been leached down from the surface and that little dilution has taken place in the process. Contour maps demonstrate that the highest values of availabe boron in the 0-5 cm and 25-30 cm soils occurred at sites closest to the Crane plant but declined with increased distance from the source (Figure 15).

Other Elements - Total Values

Total values of 10 elements found in 0-5 cm and 25-30 cm soils collected at survey sites in the vicinity of Crane have been listed in Tables 9 and 10. Values above the Phyto ULN for 0-5 cm have been underlined.

Values of total boron in 0-5 cm soil were found to be above the Phyto ULN guideline of 15 ppm at 10 of the 11 survey sites - including the control site (12) located 800 metres southeast of the Crane plant. The highest values were found at the 3 sites (1, 6, & 14) closest to the source. Contour maps generated from the data show the relationship between elevated total boron values in the 0-5 cm and 25-30 cm soils and proximity to Crane (Figure 16).

Zinc and nickel concentrations in 0-5 cm soil exceeded their respective ULNs at sites 7 and 1, respectively. At other survey sites, values of the two elements were generally elevated at locations close to the Crane plant. Although not excessive, total values of fluoride, barium and titanium were also highest in 0-5 cm and 25-30 cm soils at sites closest to the plant (Figure 17 - 19).

The Anomaly at Site 10

At this relatively distant location - approximately 850 metres north of the Crane plant, two maple varieties (silver and Norway) were originally selected in 1977 as part of the vegetation surveillance network. In 1982, the boron value in the analyzed silver maple foliage rose above the Phyto ULN guideline and has remained high annually ever since. Conversely, the boron values found in the Norway maple at the same site, have been low and relatively constant since 1977.

As part of the effort to solve this anomalous situation at site 10, the 1989 Phyto surveillance program included the usual sampling of silver and Norway maple foliage, the sampling of soil from 0-5 cm and 25-30cm depths, and the use of moss bags. Soils were sampled to determine the degree of boron contamination in the earth and the moss bags were utilized to monitor current levels of atmospheric boron emissions. In contrast to indigenous vegetation and soils, moss bags have the advantage of constant receptivity to atmospheric contamination. Moss bags cannot accumulate contaminants beyound their one month exposure period, as they have had no previous exposure to the source. Unlike vegetation, moss bags cannot be contaminated via the soil, and therefore they reflect only the current atmospheric pollution loading. In addition, most elements are held tenaciously by the moss fibres and are not subject to leaching by rainfall (sodium and chloride are noted exceptions).

As the data summary in table 2 showed, the anomaly of a high boron value in the silver maple foliage and low value in the Norway maple persisted from 1982 to 1989. Since both species are equally exposed to the same boron source, it was expected that foliar boron concentrations would be similar.

During each of three one-month exposure periods in 1989, boron values detected in moss bags at site 10 were relatively low. This evidence would suggest that the visible injury (Table 1) and the high boron value found in the silver maple foliage at this site was not as a result of current atmospheric emissions.

Values of 0.8 ppm available boron were detected in both the 0-5 cm and 25-30 cm soils sampled at site 10 (Table 8). Although the values are below the 1 ppm considered to be potentially phytotoxic, they are nevertheless surprisingly elevated compared to the much lower values found at other survey sites situated closer to the Crane plant.

With this survey, it cannot be explained how available boron values in the soil became so elevated at this relatively distant site. However, based on the moss bag evidence, it was concluded that available boron in the soil and not current atmospheric boron emissions, is the source of the visible injury and high values of the element found in the silver maple foliage at site 10. Since boron values found in the silver

maple foliage are high, it may be that this species has a greater propensity to accumulate boron from a soil source than the Norway maple.

Summary

Boron values in excess of the Phytotoxicology ULN guidelines were found in unwashed foliage at 5 sites in the vicinity of the Crane Canada plant in Stratford. Compared to 1987 values at the same 5 locations, the 1989 levels were only marginally lower. The highest foliar boron concentrations were found at sites closest to the Crane plant.

Excessive fluoride values were found in unwashed foliage at 7 sites in vicinity of the Crane plant. The highest values of the element were found at sites closest to the plant.

Foliar concentrations of copper and nickel exceeded the ULN guidelines at one or both of the two sites closest to Crane. Also, zinc, manganese, aluminum, barium and titanium foliar levels were elevated at one or more of the sample sites closest to the source.

Contour maps created from these data clearly point to the Crane plant as the source of the excessive and elevated values found in the foliage.

Exessive and potentially phytotoxic levels of available boron were found in 0-5 cm and 25-30 cm soils at 4 sites close to the Crane plant. Particularly high values were found at sites 1, 6 and 14 - all located closest to Crane. Computer-generated contour maps indicate that the Crane plant is a significant source of boron and fluoride as well as a secondary source of barium, titanium, nickel and zinc emmissions.

For a three month period in 1989, moss bags were deployed at 13 sites in the vicinity of the Crane plant to monitor current emmissions of boron, fluoride and other elements. Analysis results confirmed that bags located closest to the Crane plant contained the highest boron, fluoride, sodium, barium, titanium, copper and zinc values. The association between elevated values of these elements and proximity to the Crane plant was clearly demonstrated with contour maps.

Contour maps produced from boron values detected in vegetation, moss bags and soils clearly show a clear association between the highest values and the Crane plant. Similar associations were evident with a number of other elements in vegetation and soils and the plant.

The anomalous situation with regard to differences in foliar injury and boron content in the two sample trees at site 10 was concluded to be related to uptake of available boron from the soil and not to current boron emissions.

Appendix I

Derivation and Significance of MOE "Upper Limits of Normal" Contaminant Guidelines

The MOE "upper limits of normal" contaminant guidelines essentially represent the expected maxiumum concentration of contaminants in surface soil (non-agricultural), foliage (tree and shrub), grass, moss bags and/or snow from areas of Ontario not subject to the influence of point sources of emissions. "Urban" guidelines are based upon samples collected from centers of minimum 10,000 population. "Rural" guidelines are based upon samples collected by MOE personnel using standard sampling techniques (ref: Ministry of the Environment, 1983. Field Investigation Manual. Phytotoxicology Section - Air Resources Branch: Technical Support Sections - NE and NW Regions). Chemical analyses were performed by the MOE Laboratory Services Branch.

The guidelines were calculated by taking the arithmetic mean of available analytical data and adding three standard deviations of the mean. For those distribution that are "normal", 99% of all contaminant levels in samples from "background" locations (i.e. not affected by point sources nor agricultural activities) will lie below these upper limits of normal. For those distributions that are non-normal, the calculated upper limits of normal will not actually equal the 99th percentile, but nevertheless they lie within the observed upper range of MOE results for Ontario samples.

Due to the large variability in element concentrations which may be present across Ontario, even in background data, control samples should always be collected. This is particularly important for soils, which show large regional variations in element composition due to difference in parent material. Species of vegetation which naturally accumulate high levels of an element also may be encountered.

It is stressed that these guidelines do not represent maximum desirable or allowable levels of contaminants. Rather, they serve as levels which, if exceeded, would prompt further investigation on a case by case basis to determine the significance, if any, of the above normal concentration(s). Concentrations which exceed the guidelines are not necessarily toxic to plants, animals or man. Concentrations which are below the guidelines are not known to be toxic.

FIGURE: 1 Locations of Phytotoxicology Vegetation, Soil and Moss Bag Surveillance Sites in the Vicinity of Crane Canada Ltd., Stratford

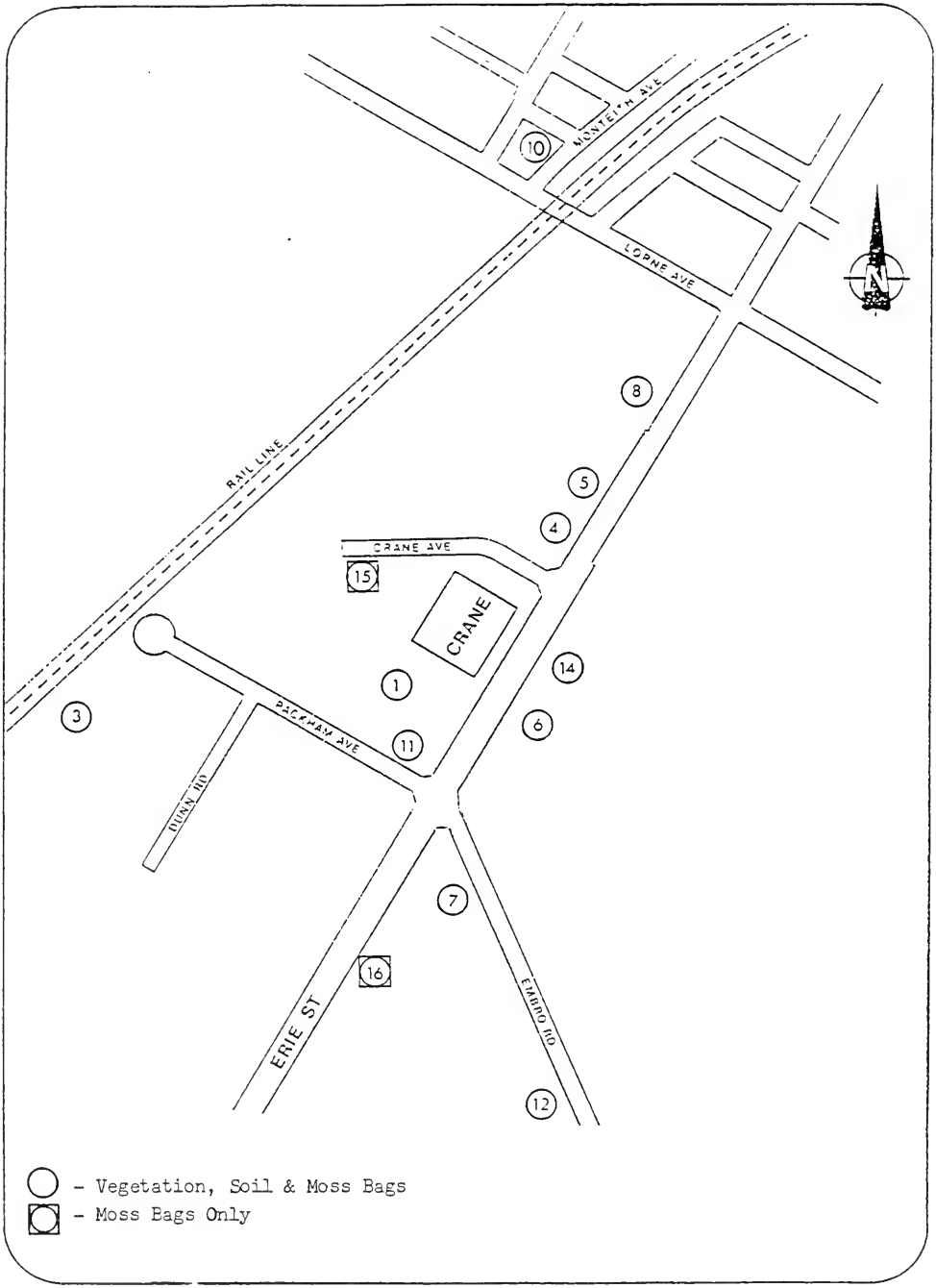
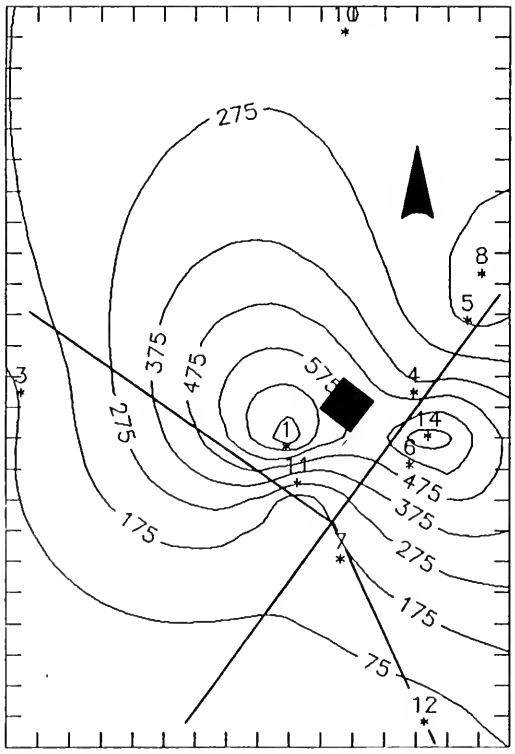
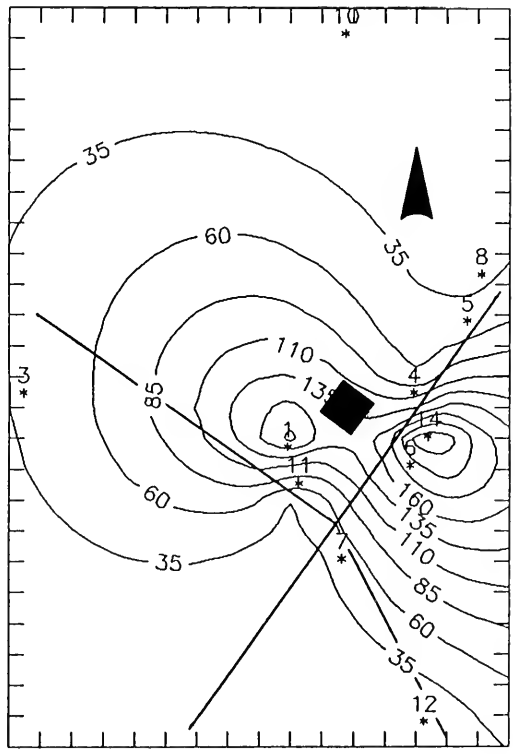


FIGURE: 2 Boron Values[1] in Foliage Collected at Sites Near Crane Canada Ltd.



Contour intervals - 100 ppm

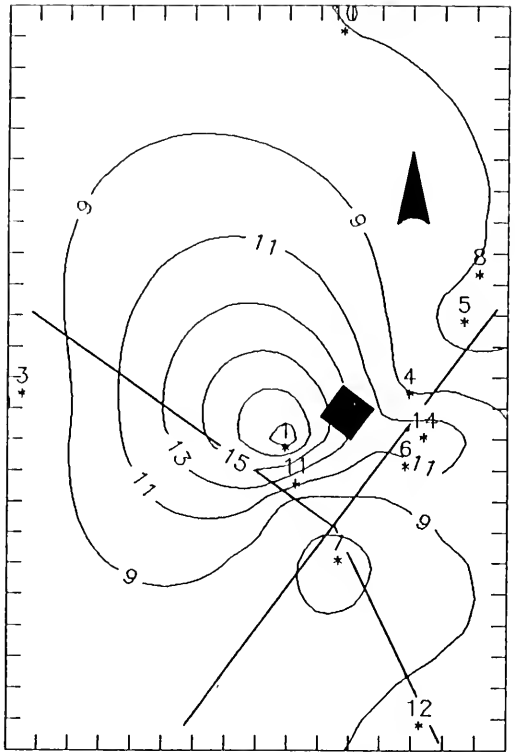
FIGURE: 3 Fluoride Values[1] in Foliage Collected at Sites Near Crane Canada Ltd.



Contour intervals - 25 ppm

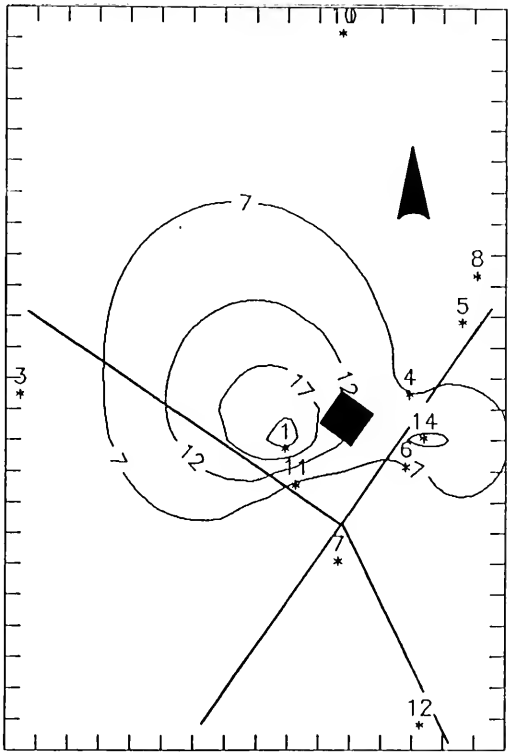
[1]Parts per million (ppm) - dry weight

at Sites Near Crane Canada Limited



Contour intervals - 2 ppm

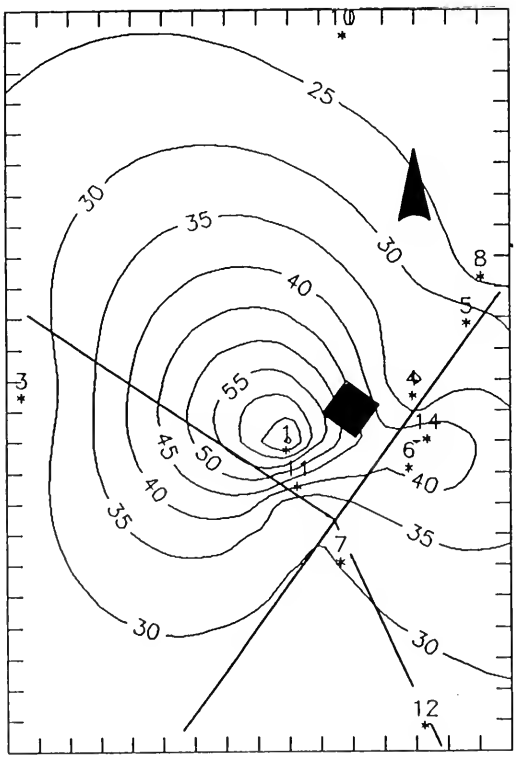
at Sites Near Crane Canada Limited



Contour intervals - 5 ppm

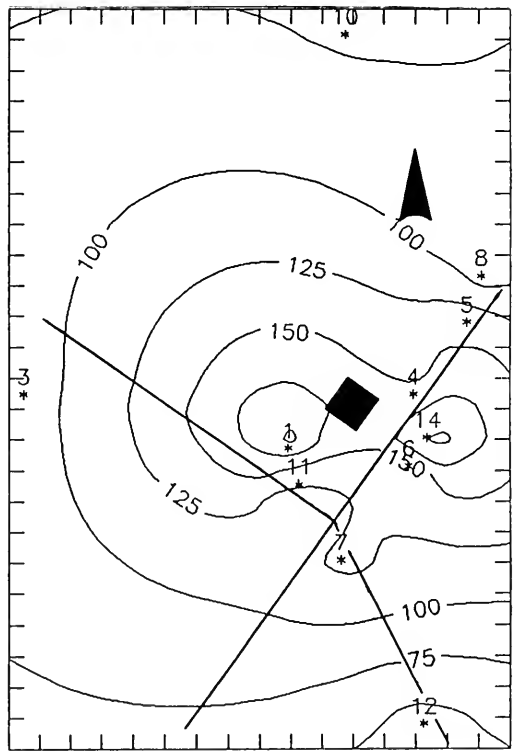
[1]Parts per million (ppm) - dry weight

FIGURE: 6 Zinc Values[1] in Foliage Collected at Sites Near Crane Canada Ltd.



Contour intervals - 5 ppm

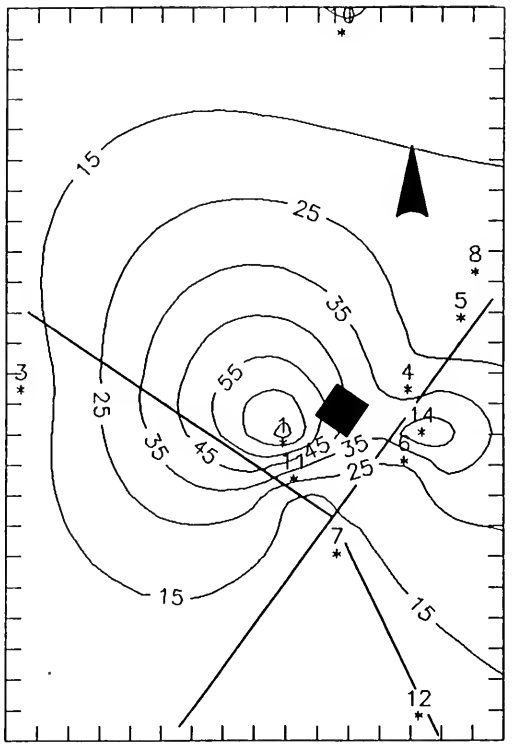
FIGURE: 7 Aluminum Values[1] in Foliage Collected at Sites Near Crane Canada Ltd.



Contour intervals - 25 ppm

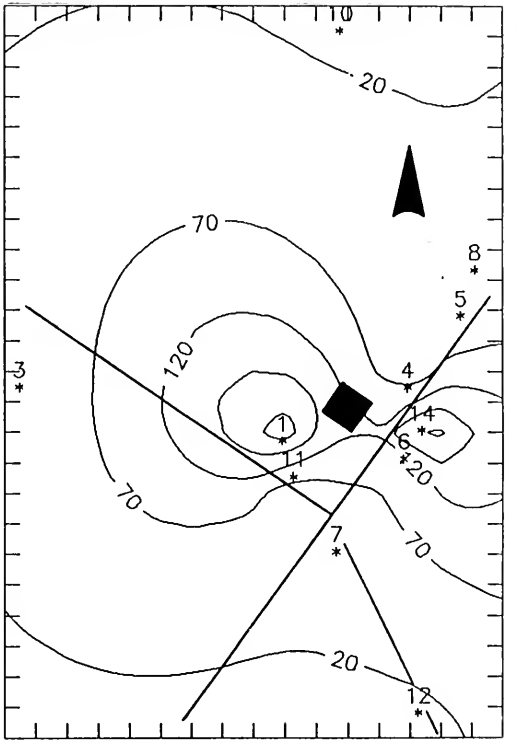
[1]Parts per million (ppm) - dry weight

FIGURE: 8 Barium Values[1] in Foliage Collected at Sites Near Crane Canada Ltd.



Contour intervals - 10 ppm

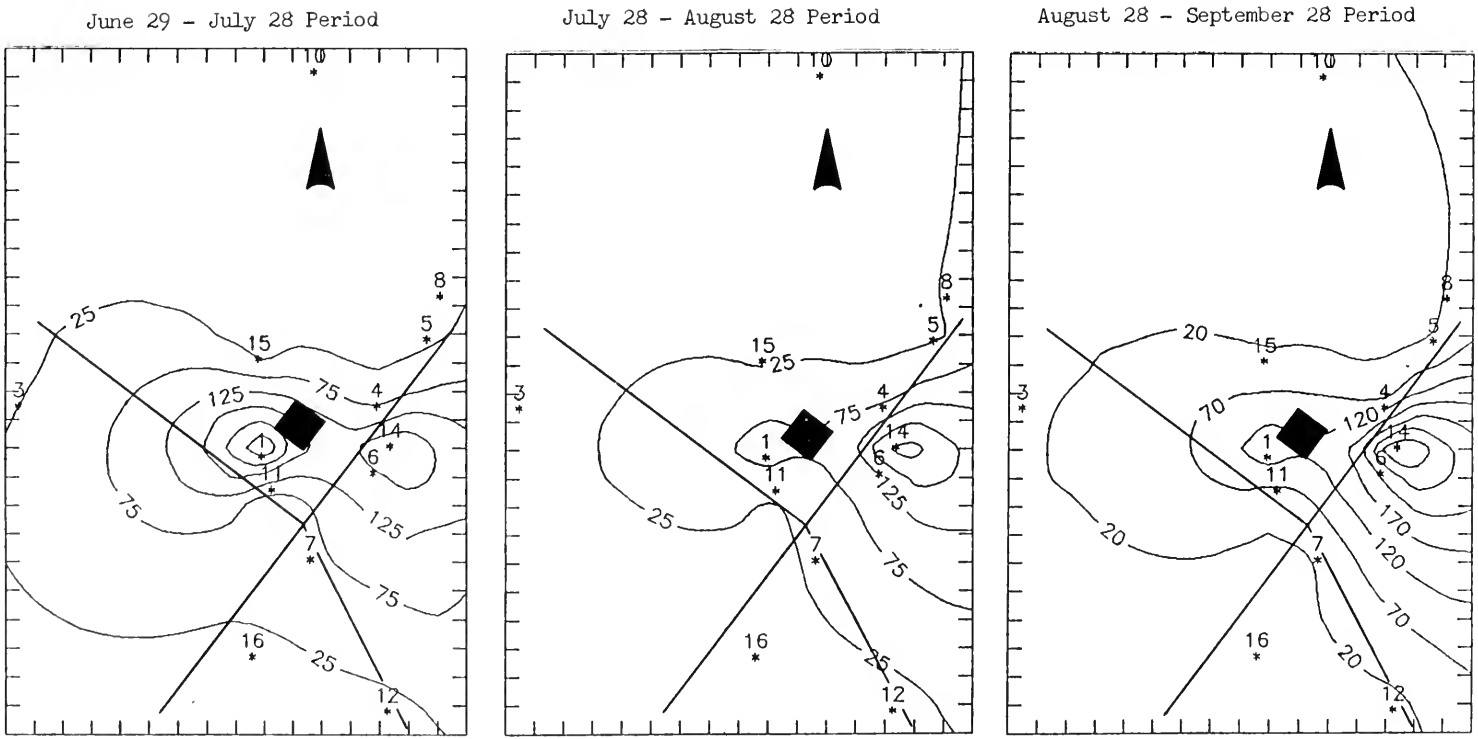
FIGURE: 9 Titanium Values[1] in Foliage Collected at Sites Near Crane Canada Ltd.



Contour intervals - 50 ppm

[1] Parts per million (ppm) - dry weight

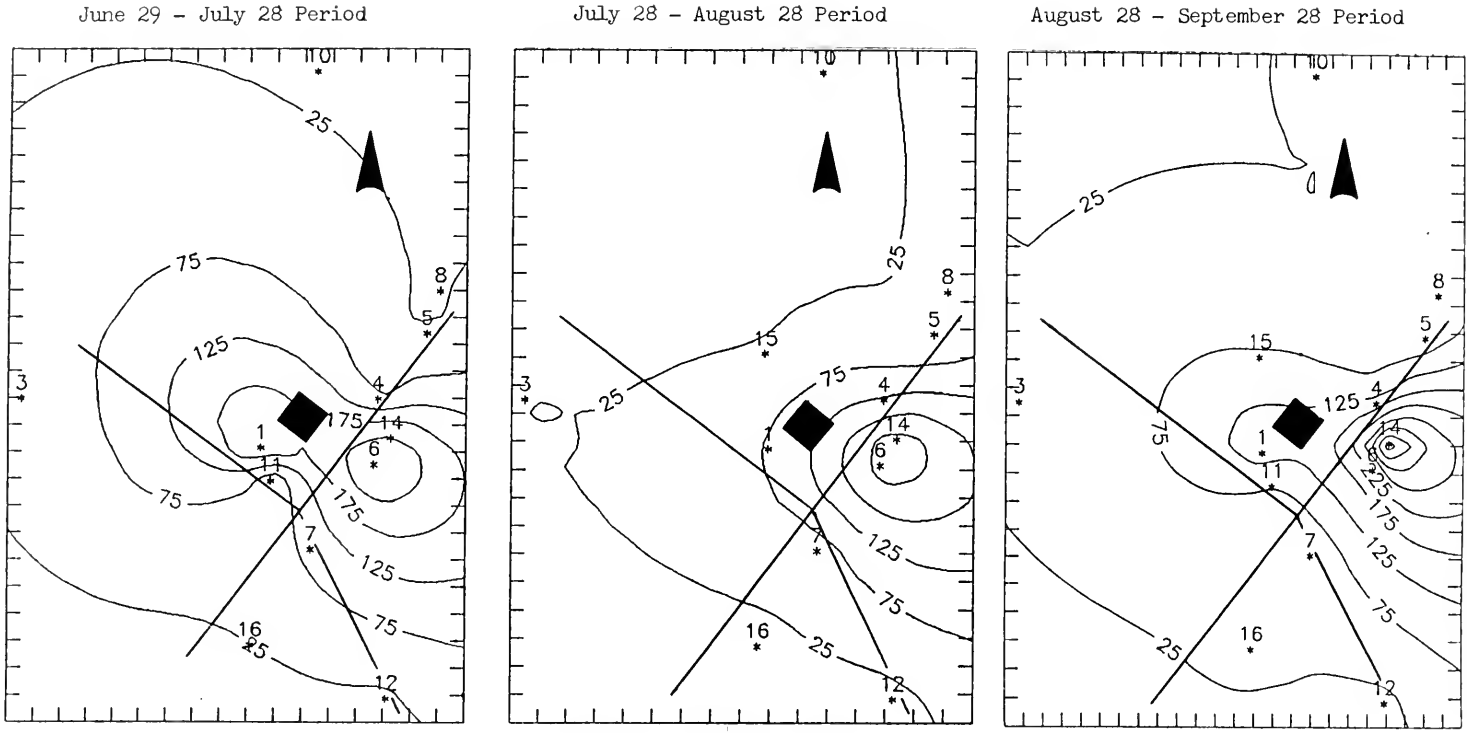
FIGURE: 10 Boron Values[1] in Moss Bags Positioned in the Vicinity of Crane Canada Ltd., Stratford During 3 Monthly Exposure Periods in 1989



Contour intervals - 50 ppm

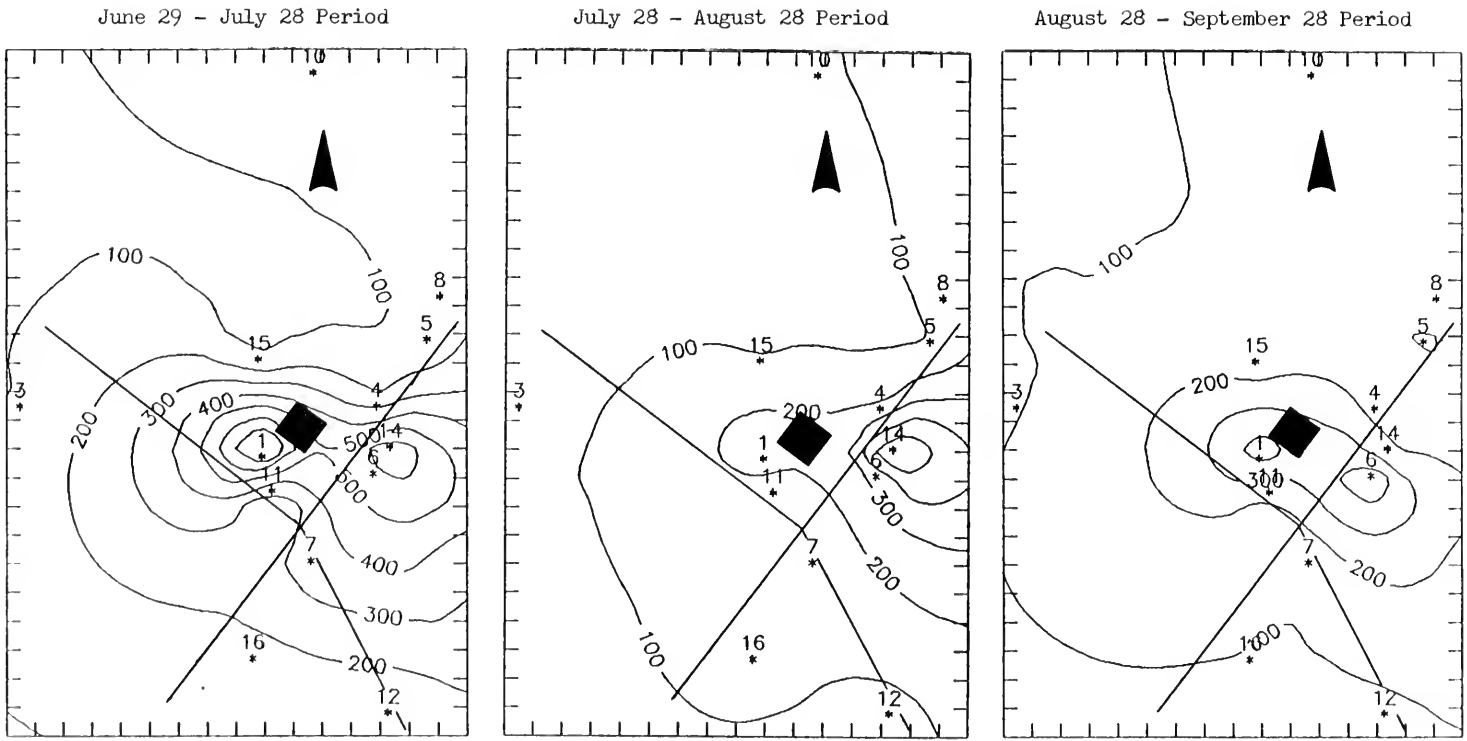
[1]Gross values - ppm, dry weight

FIGURE: 11 Fluoride Values[1] in Moss Bags Positioned in the Vicinity of Crane Canada Ltd., Stratford During 3 Monthly Exposure Periods in 1989



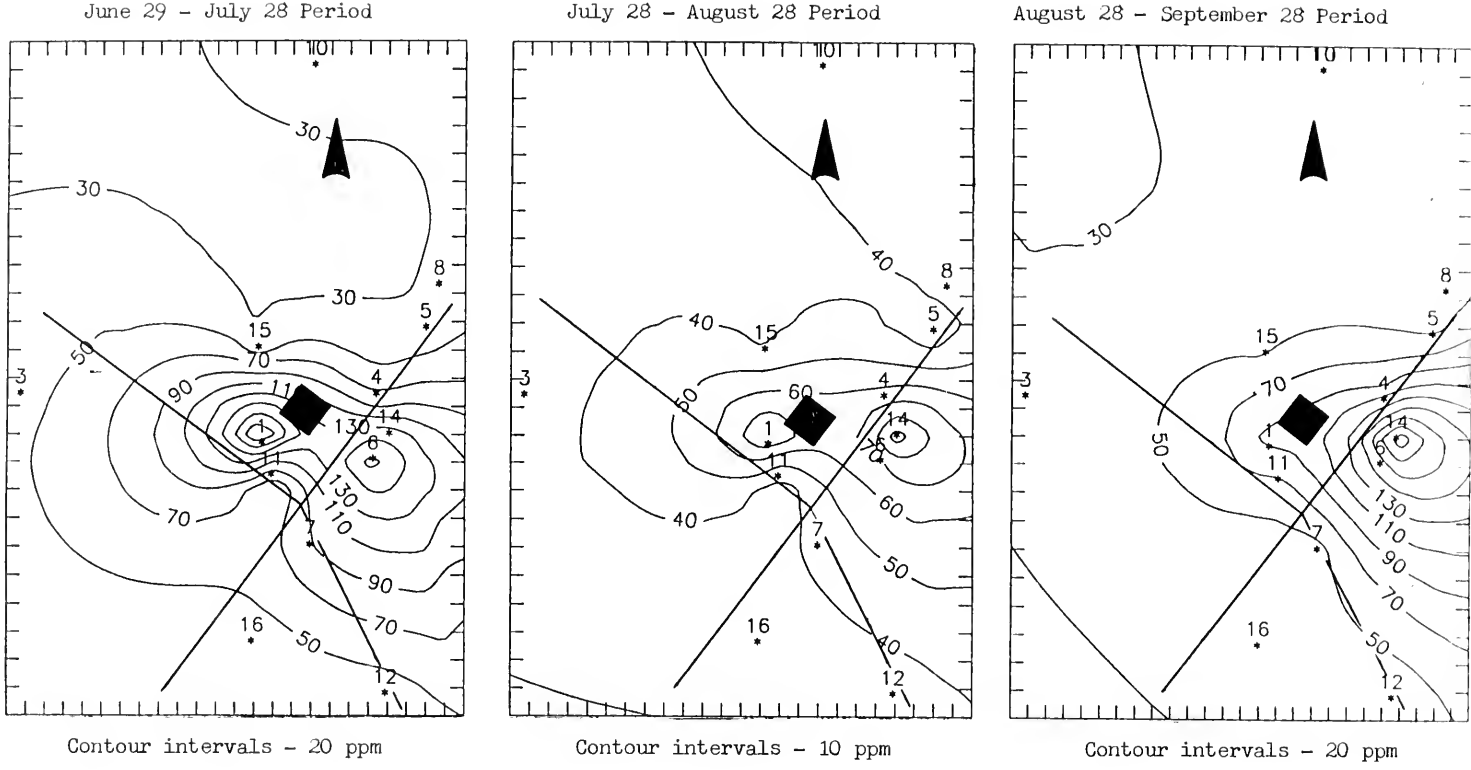
[1]Gross Values - ppm, dry weight

FIGURE: 12 Sodium Values[1] in Moss Bags Positioned in the Vicinity of Crane Canada Ltd., Stratford During 3 Monthly Exposure Periods in 1989



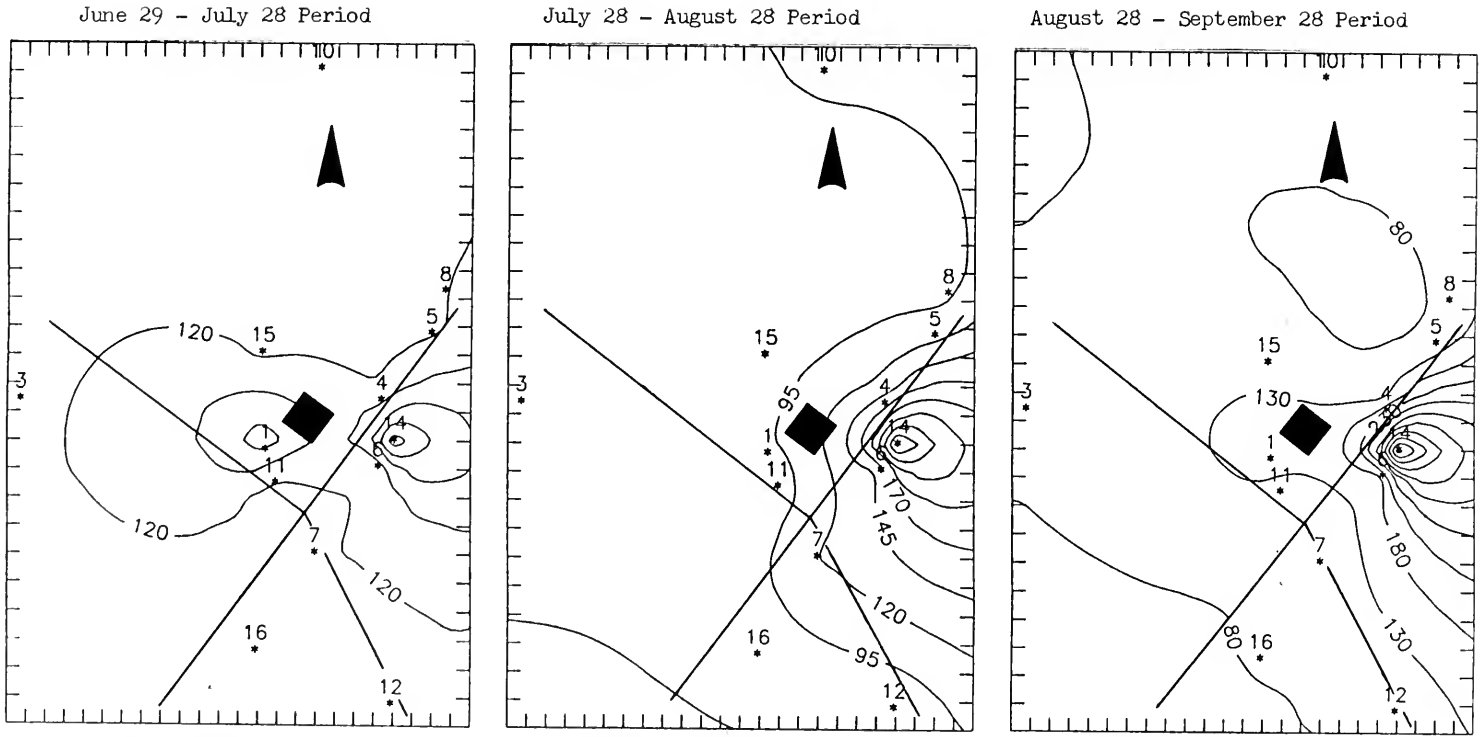
[1]Gross values - ppm, dry weight

FIGURE: 13 Barium Values[1] in Moss Bags Positioned in the Vicinity of Crane Canada Ltd., Stratford During 3 Monthly Exposure Periods in 1989



[1]Gross Values - ppm, dry weight

FIGURE: 14 Titanium Values[1] in Moss Bags Positioned in the Vicinity of Crane Canada Ltd., Stratford During 3 Monthly Exposure Periods in 1989



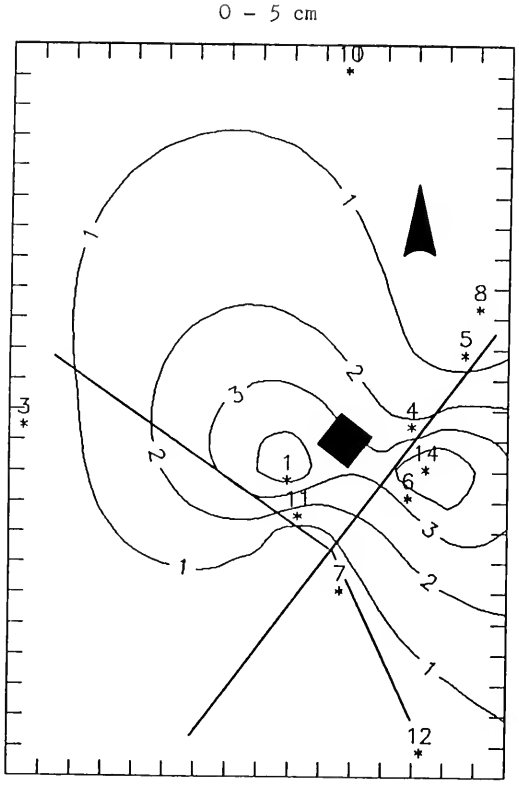
Contour intervals - 50 ppm

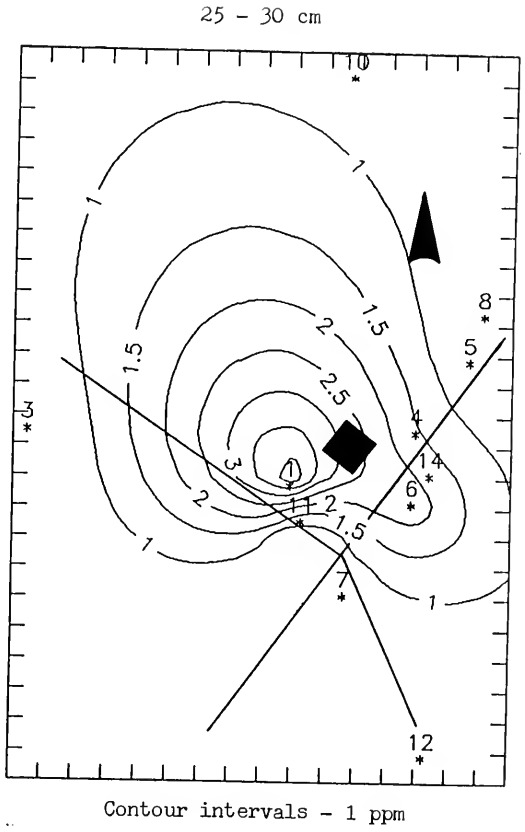
Contour intervals - 25 ppm

Contour intervals - 50 ppm

[1]Gross Values - ppm, dry weight

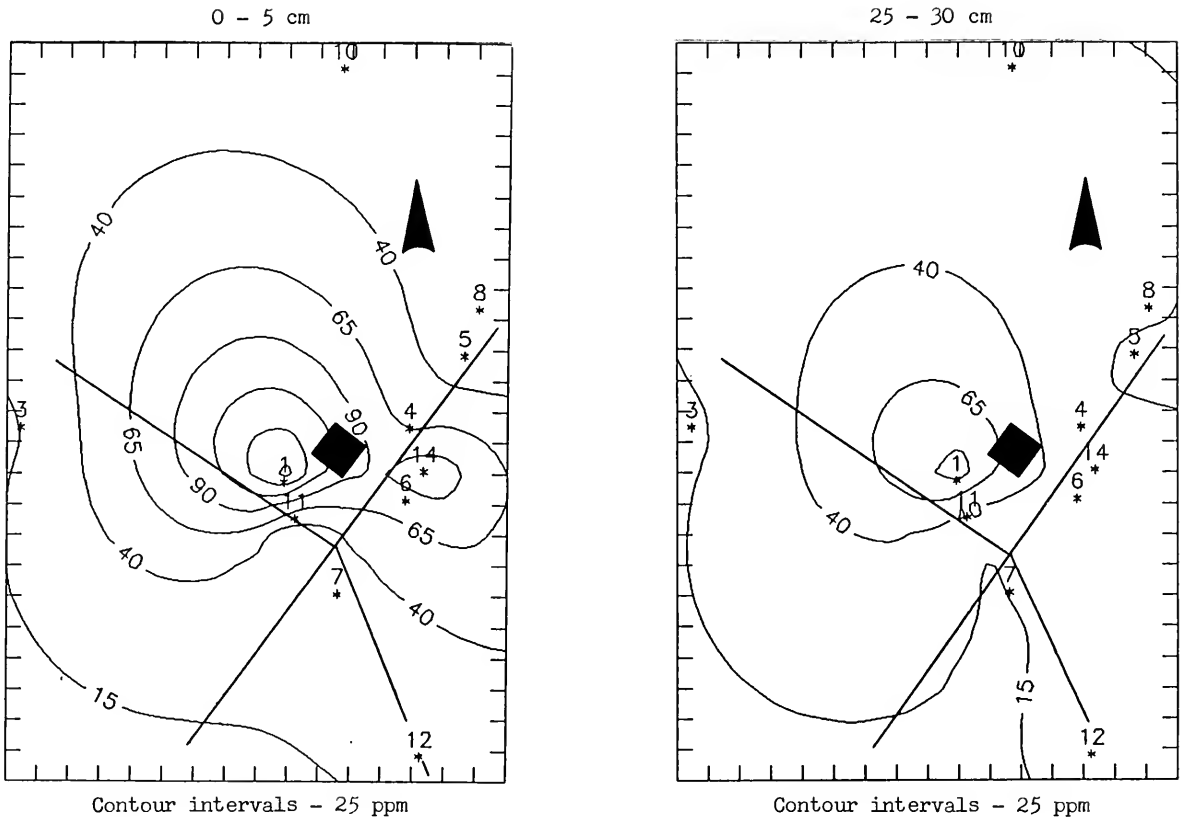
FIGURE: 15 Values[1] of Available Boron Found in 0-5 cm and 25-30 cm Soils Collected at Sites Near Crane Canada Ltd., 1989





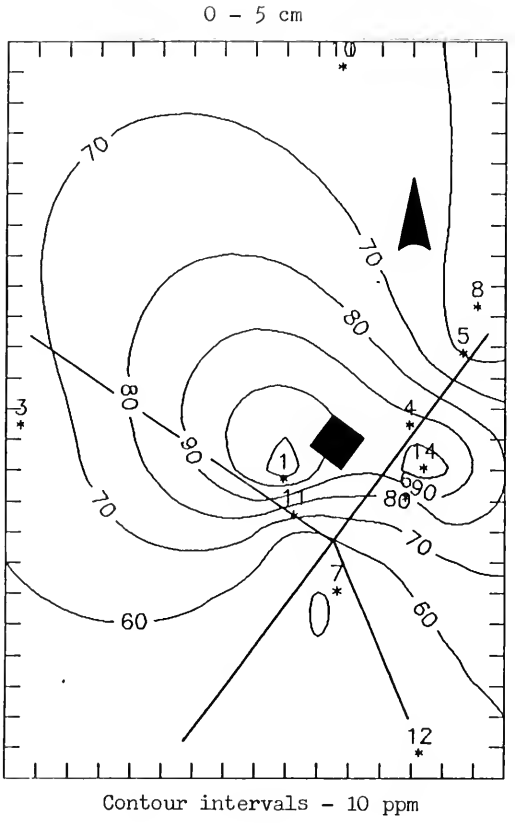
[1]parts per million (ppm), dry weight

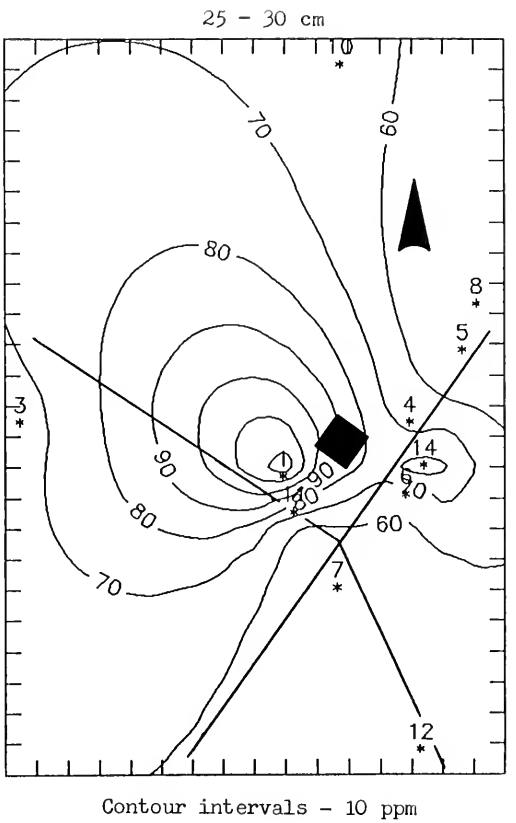
FIGURE: 16 Values[1] of Total Boron Found in 0-5 cm and 25-30 cm Soils Collected at Sites Near Crane Canada Ltd., 1989



[1]Parts per million (ppm), dry weight

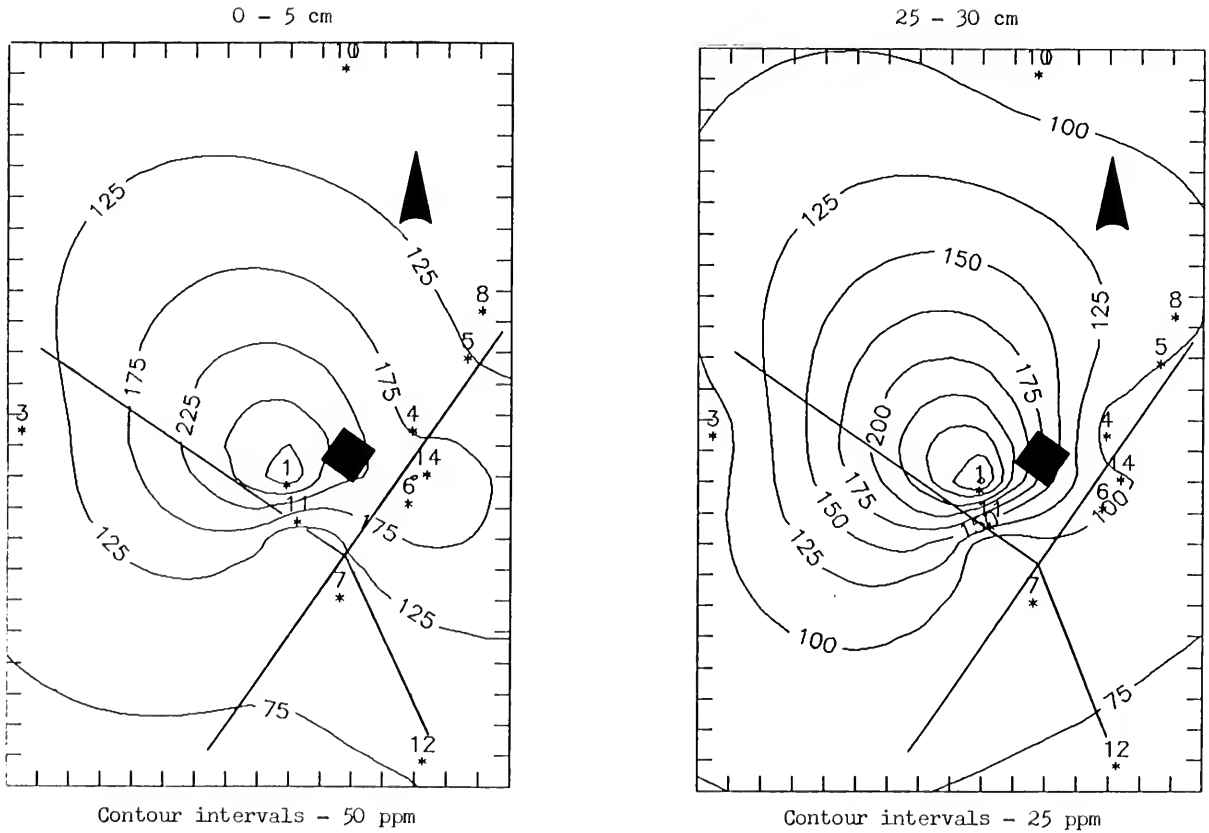
FIGURE: 17 Values[1] of Fluoride Found in 0-5 cm and 25-30 cm Soils Collected at Sites Near Crane Canada Ltd., 1989





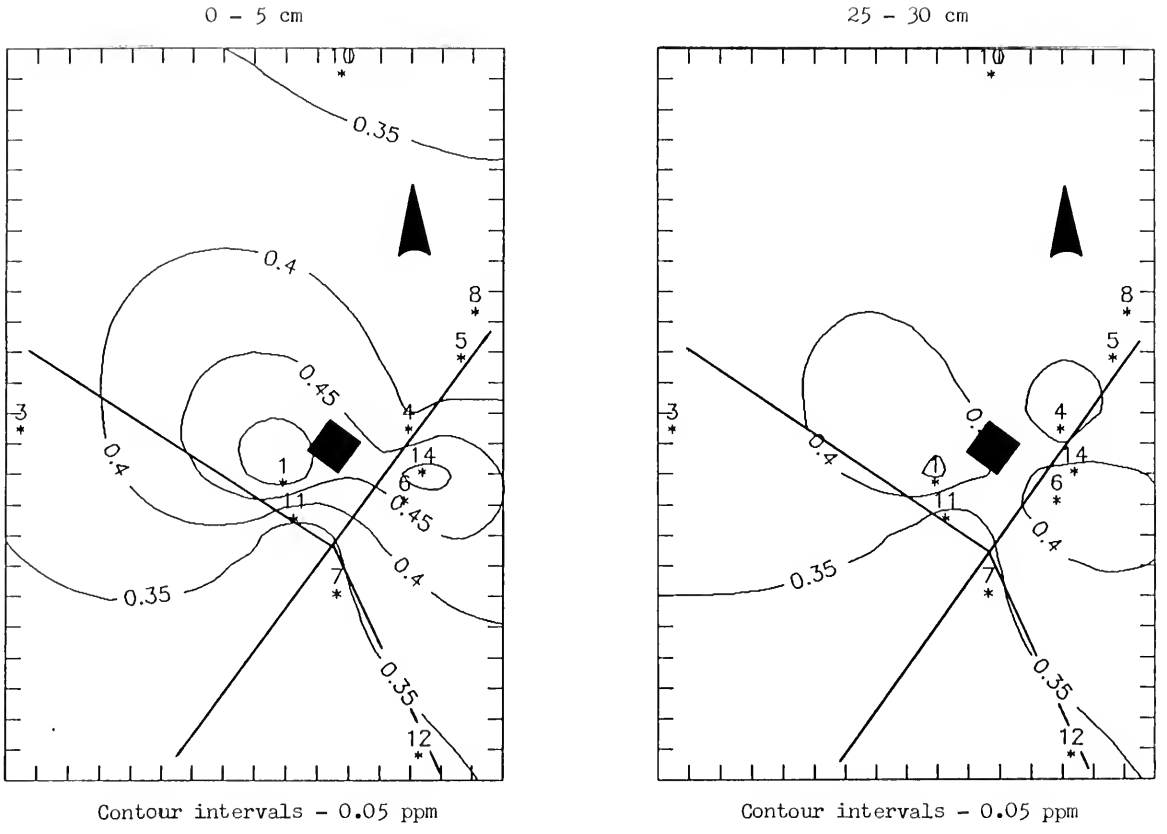
[1]Parts per million (ppm), dry weight

FIGURE: 18 Values[1] of Barium Found in 0-5 cm and 25-30 cm Soils Collected at Sites Near Crane Canada Ltd., 1989



[1]Parts per million (ppm), dry weight

FIGURE: 19 Values[1] of Titanium Found in 0-5 cm and 25-30 cm Soils Collected at Sites Near Crane Canada, Ltd., 1989



[1]Parts per million (ppm), dry weight

TABLE: 1

Comparative Boron-Type Foliar Injury Severity
at 11 Sample Sites in the Vicinity of Crane Canada Limited
1984 - 1989

Sample Site Number	Sample Species	Approx. Distance & Direction from Crane Canada	Visual Injury Rating[a] 1984	1985	1986	1987	1989
1	silver maple	125m W	4	4	NA	4	4
1	ash[b]	125m W	4	3	NA	3	4
3	silver maple	700m W	0	0	0	0	0
4	Norway maple	150m ENE	2[c]	3	NA	3	3
5	Norway maple	200m NE	1	0	2	3	1
6	silver maple	150m SE	2[c]	3	NA	2	2
7	silver maple	425m S	0	2	NA	2	2
8	silver maple	450m NE	0	0	0	0	1
8	Norway maple	450m NE	0	0	0	0	1
10	silver maple	850m N	0	0	2	1	1
10	Norway maple	850m N	0	0	0	0	0
11	Norway maple	300m SSW	0	1	0	1	1
12[d]	silver maple	800m SE	0	0	0	0	0
12[d]	green ash	800m SE	0	0	NA	0	0
14	Norway maple	150m S	NE	NE	NE	NE	3

[a] Phytotoxicology injury rating scale (percent of leaf area affected)
0 - normal, 1 - >0-1%, 2 - 2-10%, 3 - 11-35%, 4 - >35%, 5 - 100%.

[b] Green ash sampled in 1986, 1987, 1989, white ash in 1984 & 1985.

[c] Injury symptoms partially obscured by senescence

[d] Control location.

NA - No injury evaluation possible due to senescence.

NE - Site not established prior to 1989.

TABLE: 2

Boron Concentrations in Unwashed Foliage Collected at 11 Surveillance Sites Near Crane Canada Limited, Stratford

1977 - 1989

Sample Site Number	Vegetation Sampled	Boron Concentration (ppm - dry weight)										
		1977	1978	1980	1981	1982	1983	1984	1985	1986	1987	1989
1	silver maple	366	667	395	563	700	674	583	457	280	990	880
1	white ash[1]	NS	NS	NS	NS	375	267	350	357	200	570	420
3	silver maple	NS	54	66	39	65	77	52	59	55	87	61
4	Norway maple	NS	NS	178	200	390	311	250	283	180	457	370
5	Norway maple	NS	NS	141	184	195	249	190	130	140	194	138
6	silver maple	NS	NS	290	NS	390	467	560	433	130	789	515
7	silver maple	NS	123	135	158	155	170	107	107	100	127	155
8	silver maple	113	NS	104	100	110	153	113	133	120	145	145
8	Norway maple	NS	NS	81	75	135	133	113	94	95	119	90
10	silver maple	71	59	NA	118	380	350	347	317	260	450	250
10	Norway maple	NS	68	79	66	100	82	102	80	72	80	70
11	Norway maple	NS	NS	130	112	165	135	123	100	100	110	115
12[2]	silver maple	NS	41	49	66	60	62	63	30	24	NS	27
12[2]	green ash	NS	NS	NS	NS	55	68	54	63	50	43	30
14	Norway maple	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	835
Phytotoxicology ULN		**200**	**200**	**200**	**200**	**200**	**200**	**200**	**175**	**175**	**175**	**175**

[1] Green Ash sampled from 1986 to 1989. [2] Control site. NS - Not sampled. NA - Data unavailable

TABLE: 3 Fluoride Concentrations in Unwashed Foliage Collected in the Vicinity of Crane Canada Limited, Stratford 1989

Sample Site Number	Sample Species	Fluoride Concentration (ppm - dry weight)
1	silver maple	200
1	green ash	175
3	silver maple	36
4	Norway maple	64
5	Norway maple	41
6	silver maple	195
7	silver maple	42
8	silver maple	30
8	Norway maple	17
10	silver maple	13
10	Norway maple	9
11	Norway maple	31
12	silver maple	13
12	green ash	14
14	Norway maple	290
Phytotoxicology Upper Limit of Normal for unwashed urban foliage		**35**

TABLE: 4 Concentrations of 10 Elements Found in Unwashed Foliage Collected in the Vicinity of Crane Canada Ltd., Stratford - 1989

Sample Site	Sample Species	Element Concentration (ppm-dry weight)[1]									
		Cu	Ni	Pb	Zn	Fe	Mn	Al	Ba	S	Ti
1	silver maple	21	26	2	74	125	63	210	83	0.2	260
1	green ash	21	23	1	43	82	38	160	84	0.2	195
3	Norway maple	7	1	2	25	120	24	87	8	0.2	25
4	Norway maple	8	5	2	27	175	19	145	25	0.3	34
5	Norway maple	6	4	2	34	185	43	145	16	0.2	36
6	silver maple	10	5	2	40	130	43	130	22	0.2	91
7	silver maple	6	2	3	30	190	48	135	14	0.2	39
8	silver maple	7	2	1	23	145	51	88	20	0.2	27
8	Norway maple	6	1	2	20	130	27	77	12	0.2	22
10	silver maple	7	1	2	22	160	36	72	5	0.2	14
10	Norway maple	7	1	2	30	225	24	125	7	0.2	27
11	Norway maple	9	1	2	31	125	30	102	13	0.3	38
12	silver maple	10	1	1	28	79	23	38	11	0.1	12
12	green ash	22	2	1	31	86	29	48	30	0.1	13
14	Norway maple	14	16	2	49	125	43	230	62	0.2	285
Phytotoxicology ULN		**20**	**7**	**60**	**250**	**1000**	NE	**500**	NE	**0.4%**	NE

[1] Sulphur results given in percent (%-dry weight)

NE - ULN not established for these elements

TABLE: 5 Values of 10 Elements Detected in Moss Bags at 13 Sites in the Vicinity of Crane Canada Ltd., Stratford During the Monthly Exposure Period June 29 - July 28, 1989

Moss Bag Site No.	Element Concentration (ppm - dry weight)									
	B	F	Na	Ba	Ti	Cu	Zn	Mn	Al	Mg
1	350	250	960	230	260	40	78	180	1300	1000
3	23	34	110	43	110	8	68	100	1100	1000
4	45	67	220	61	130	12	89	150	990	1600
5	11	23	100	35	110	27	460	120	1000	1300
6	160	290	570	180	130	31	67	170	1200	1300
7	66	88	370	89	120	17	69	150	1000	1600
8	14	23	170	34	120	6	55	110	970	1200
10	10	19	180	37	96	8	60	140	1100	1800
11	19	25	150	41	90	7	63	130	780	1200
12[1]	12	17	110	40	75	7	54	120	920	1100
14	260	250	720	140	360	22	74	150	1400	1400
15	14	NA	92	37	110	8	51	130	1000	1500
16	13	24	160	38	92	8	68	130	960	1500
Phyto ULN's	NE	NE	NE	NE	NE	60	800	NE	NE	NE

[1]Control site NA - Fluoride value not available

NE - ULN not established

TABLE: 6 Values of 10 Elements Detected in Moss Bags at 13 Sites in the Vicinity of Crane Canada Ltd., Stratford During the Monthly Exposure Period July 28 - August 28, 1989

Moss Bag Site No.	Element Concentration (ppm - dry weight)									
	B	F	Na	Ba	Ti	Cu	Zn	Mn	Al	Mg
1	110	79	300	85	92	14	62	150	930	910
3	16	26	71	36	88	6	57	100	820	1000
4	58	120	180	62	140	17	72	96	1200	1700
5	13	22	85	30	110	12	85	90	990	1200
6	110	250	300	68	150	13	74	100	1100	1500
7	30	44	120	43	120	11	82	120	1000	1600
8	30	40	140	46	89	8	63	130	840	1300
10	12	20	95	44	99	7	65	120	840	1400
11	18	NA	100	33	81	7	140	100	980	1100
12[1]	7	11	68	35	75	5	67	110	980	990
14	290	260	690	96	310	16	75	120	1100	1300
15	19	28	100	39	84	6	74	110	930	1100
16	12	20	130	33	81	8	100	110	850	1200
Phyto ULN's	NE	NE	NE	NE	NE	60	800	NE	NE	NE

[1]Control site NA - Fluoride value not available

NE - ULN not established

TABLE: 7 Values of 10 Elements Detected in Moss Bags at 13 Sites in the Vicinity of Crane Canada Ltd., Stratford During the Monthly Exposure Period August 28 - September 28, 1989

Moss Bag Site No.	Element Concentration (ppm - dry weight)									
	B	F	Na	Ba	Ti	Cu	Zn	Mn	Al	Mg
1	170	170	480	99	180	15	62	140	1100	940
3	15	35	94	35	89	8	62	110	980	970
4	60	110	180	100	130	22	130	150	1200	1500
5	17	37	80	46	92	37	300	150	990	1400
6	210	210	510	160	170	27	79	140	1200	1100
7	16	32	110	41	92	10	71	130	1000	1300
8	23	42	160	40	95	8	55	120	1300	1300
10	12	20	95	44	99	7	65	120	840	1400
11	32	57	180	63	96	11	130	150	990	1000
12[1]	6	14	84	35	90	5	69	120	1100	940
14	430	465	180	230	630	37	140	160	1300	1100
15	26	79	130	48	110	8	77	110	1200	890
16	12	37	100	42	84	10	150	130	1000	1000
Phyto ULN'S	NE	NE	NE	NE	NE	60	800	NE	NE	NE

[1]Control site NE - ULN not established

TABLE: 8 Available Boron Concentrations[1] in Soils Collected from 0-5 cm and 25-30cm Depths in the Vicinity of Crane Canada Ltd., Stratford - 1989

Soil Sample Site Number	Available Boron Concentration (ppm - dry weight) 0-5 cm	25-30 cm
1	5.1	4.5
3	0.3	0.2
4	1.7	1.5
5	0.5	0.5
6	3.0	2.4
7	0.6	0.5
8	0.5	0.4
10	0.8	0.8
11	0.5	0.2
12	0.3	0.2
14	6.3	1.8

[1] Concentrations of available boron (determined by the hot water extract method) above 1 ppm in soils are considered phytotoxic to plant foliage.

TABLE: 9 Total Values[1] of 10 Elements Detected in 0-5 cm Soils Collected at Surveillance Sites in the Vicinity of Crane Canada Ltd., Stratford - 1989

Survey Site No.	Element Concentration (ppm - dry weight)									
	B	F	Ba	Ti	Cu	Zn	Mn	Al[2]	Ni	Pb
1	180	118	375	0.56	58	260	460	2.0	72	42
3	12	62	88	0.36	41	97	260	1.0	19	24
4	53	93	155	0.40	36	130	480	2.1	33	54
5	25	56	125	0.36	42	100	660	2.5	29	38
6	72	77	215	0.46	35	235	380	1.8	42	71
7	28	49	100	0.34	43	530	430	1.9	24	107
8	23	55	110	0.36	32	110	505	1.9	23	45
10	24	64	84	0.34	26	92	445	1.7	17	53
11	16	61	75	0.30	32	64	455	1.5	18	24
12[3]	20	57	78	0.34	48	85	245	1.7	16	26
14	125	114	235	0.55	30	230	305	1.7	47	59
Phyto ULN's	15	NE	NE	NE	**100**	**500**	**700**	NE	**60**	**500**

[1]Average of duplicate sample results.

[2]aluminium results - percent (%) dry weight

[3]Control site NE - ULN not established

TABLE: 10 Total Values[1] of 10 Elements Detected in 25-30 cm Soils Collected at Surveillance Sites in the Vicinity of Crane Canada Ltd., Stratford - 1989

Survey Site No.	Element Concentration (ppm - dry weight)									
	B	F	Ba	Ti	Cu	Zn	Mn	Al[2]	Ni	Pb
1	106	130	320	0.47	43	220	465	2.1	63	46
3	10	65	86	0.37	19	81	235	1.9	18	21
4	15	61	80	0.31	26	76	385	1.6	18	23
5	11	50	100	0.36	40	75	570	2.0	23	22
6	29	61	100	0.44	31	105	340	1.9	20	30
7	15	52	89	0.34	33	305	360	1.7	19	75
8	18	40	110	0.38	38	85	585	2.1	23	29
10	17	65	88	0.38	24	84	350	1.9	17	46
11	16	60	74	0.29	27	55	470	1.6	17	14
12[3]	17	58	72	0.34	55	79	200	1.8	15	19
14	43	110	235	0.43	37	95	260	1.8	20	24
Phyto ULN's	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

[1] Average of duplicate sample results.

[2] aluminium results - percent (%) dry weight

[3] Control site NE - ULN not established